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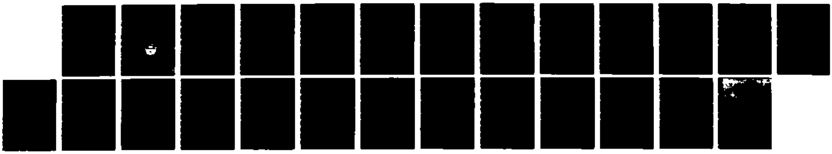

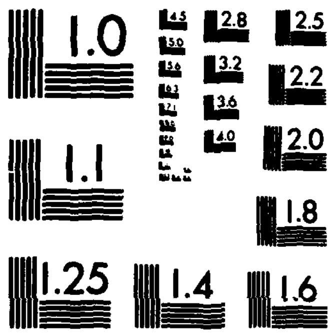

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QUALITY ASSESSMENT OF A NAVY OPERATOR TRAINING COURSE

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Although Navy technical personnel are often required to perform cognitively complex tasks, training in most Navy technical schools still relies on instructional methods designed for teaching procedural tasks. The quality of instruction at a Navy operator school designed to teach passive acoustic analysis was evaluated using three criteria: (1) the structural organization of the course, (2) the quality of feedback and remediation, and (3) testing methods used to evaluate student performance. Deficiencies found in the structural organization of the course included no clear conceptual

model of the task, an overemphasis on discrete facts, and presentation of topics that were not practiced or tested as skills. Deficiencies in the quality of feedback included little diagnosis of repeated subprocedure errors and, because of the lack of a clear conceptual model of the task, no way for students to evaluate their own performance. Provision for remediation of specific problem areas in the task was poor. Deficiencies in testing were noted because of the emphasis on recognizing discrete facts rather than demonstrating conceptual understanding of the task. Recommendations for course improvements were made.

FOREWORD

This research and development was performed in response to recognized Navy needs for an investigation of the effects of initial training and job conditions on skill retention under subproject RF63-522-801-014 (Computer-aided and Classroom Training), work unit 03.03 (Skill and Knowledge Retention). In previous work conducted to investigate relationships, problems were observed in the retention of knowledge and skills required to perform acoustic analysis.

The objectives of the subproject are to (1) derive ways of detecting potential problems existing in the Navy and (2) recommend means to minimize performance deterioration by restructuring training and job conditions. The objective of this effort was to evaluate the methods used to train and test aviation antisubmarine warfare operators (AWs) in the complex skill of passive acoustic analysis and classification. Results are intended primarily for the Anti-Submarine Warfare Wing, Pacific, the Fleet Aviation Specialized Operational Training Group, Pacific (FASOTRAGRUPAC), and other agencies at FASOTRAGRUPAC concerned with passive acoustic sonar operator training and testing. They should also be of interest to agencies responsible for the development of skill acquisition and maintenance programs for personnel in other technical ratings.

Appreciation is expressed to the members of the instructor staff at the AW Common Core Acoustic Analysis School, FASOTRAGRUPAC, for their time and efforts in collecting material for this report. Particular appreciation is expressed to AWCS Terry Burkette, AWC Henry Stanley, and Mr. Paul Lawson for their support.

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SUMMARY

Problem

Technical personnel in the Navy are required to perform tasks that range in difficulty from simple, ordered procedural tasks to highly complex cognitive tasks. As the Navy becomes more reliant upon sophisticated, complex defense systems to meet mission requirements, there is an increased need to improve instruction designed to teach operators and technicians to perform the complex cognitive tasks required in their jobs. However, training in most Navy technical schools still relies on instructional methods designed for teaching procedural tasks. Aviation antisubmarine warfare operators (AWs) destined to be assigned to Pacific Fleet carriers receive training in the complex task of acoustic analysis and classification at the AW Common Core Acoustic Analysis School, Fleet Aviation Specialized Operational Group, Pacific (FASOTRAGRUPAC). The quality of instructional and testing methods used to teach this complex task needs to be evaluated.

Objective

The objective of this effort was to evaluate the quality of instructional methods used to teach and test the complex task of acoustic analysis and classification at the Common Core course, and to provide recommendations for course changes that would improve initial acquisition and long-term retention of the skills and knowledge required to perform that task.

Approach

The teaching and testing methods used at the Common Core course were evaluated in terms of three criteria: (1) structural organization of the course, (2) quality of feedback and remediation, and (3) testing methods used to evaluate student performance.

Results

1. The structural organization of the course was found to have four deficiencies: (a) no clear conceptual model of the task, (b) an overemphasis on learning discrete facts that requires large amounts of rote memorization, (c) two topic areas presented in the course that are not practiced or tested as skills, and (d) terminal learning objectives that do not require the students to perform the task.

2. The quality of feedback and remediation was found to have three deficiencies: (a) the quality of diagnostic feedback for repeated errors in subprocedures was inadequate, (b) students have no way of evaluating their own performance, in large part because of the lack of an appropriate conceptual model of the task, and (c) there is no systematic approach to remediating poorly understood knowledge or procedural skills.

3. Testing methods were found to be deficient in testing knowledge factors primarily because of the emphasis on recognition of discrete facts rather than on the conceptual understanding of fundamental relationships required by the task.

Conclusions

1. Although this evaluation revealed a number of deficiencies in course organization, diagnostic feedback, and testing methods, instructor attitude was not cited as a

problem. It is very likely that these deficiencies have been in part overcome by individual instructor efforts. However, relying on this type of unsystematic approach cannot ensure high quality graduates of this school.

2. The course, as it is presently being taught, does not explicitly provide the student with a qualitative understanding of the relationship between sound source generators and their representations on the lofargram. The development and use of a model should provide a better conceptual understanding of this relationship, aid the student in the initial acquisition of the skills and knowledge underlying acoustic analysis and classification techniques, provide a better structure for the retention of the procedural skills and the memorized acoustic intelligence data base, and aid instructors in curriculum development, classroom demonstrations, and test development.

3. Although the student is provided with feedback about performance on knowledge and procedural skills, little individual feedback is directed toward diagnosing and correcting repeated errors caused by conceptual misunderstandings. In addition, remediation material that specifically addresses the errors made by students in classroom work or on tests is needed.

4. Tests of knowledge factors do not presently require the students to demonstrate conceptual understanding of the material but, rather, to employ rote memorization techniques that may mask inadequate conceptual understanding of the task.

Recommendations

It is recommended that FASOTRAGRUPAC support the following actions:

1. Improve the course by development and use of a conceptual model designed to increase the student's understanding of the relationship between sound source generators and their representation of the lofargram. This model can be fully integrated into the course curriculum.

2. Ensure that information presented in the oceanography and sonobuoy segments of the course is taught, practiced, and tested as skills needed to perform acoustic analysis and classification. If practical application of that information cannot be accomplished in this course, those segments may be moved to a more appropriate point in the training pipeline.

3. Ensure that course objectives require students to perform the skill of acoustic analysis and classification on the lofargram.

4. Ensure that instructors provide diagnostic feedback to individual students about conceptual errors in their understanding of the task, as evidenced by repeated errors in subprocedures.

5. Ensure that remediation of students who perform poorly on classroom work or on tests is directed toward correcting the specific poor performance rather than requiring the students to study new material for a longer period of time.

6. Ensure that tests assess the student's level of conceptual understanding of the materials presented in the course, and that test questions assess the student's ability to recall rather than recognize factual information.

CONTENTS

INTRODUCTION

Problem and Background

Navy technical personnel are required to perform tasks that range in difficulty from simple, ordered procedural tasks to highly complex, cognitive tasks. Training in most Navy technical schools still relies on instructional methods designed for teaching uncomplicated procedural tasks. As the Navy becomes more reliant upon sophisticated, complex defense systems to meet mission requirements, there is an increased need to improve instruction designed to teach operators and technicians to perform the complex, cognitive tasks required in their jobs.

The training methods presently used in many Navy technical courses are not adequate to prepare technical personnel to operate and maintain these complex systems under the wide variety of conditions encountered in the operational environment. Technical personnel are expected to learn difficult subject areas, perform multiple complex procedures, and memorize large factual data bases through courses that are poorly organized, overly detailed, and not designed to teach or test cognitively complex tasks. This approach to teaching ignores important relationships between topics, does not provide a good conceptual model of the task, and emphasizes recognition of facts rather than understanding of principles. Because of these failings, it is likely that trainees will not be able to understand the cognitively complex material presented completely and that their retention of the skills and knowledge learned will be poor.

Aviation antisubmarine warfare operators (AWs) assigned to the aviation community's S-3A platform and destined for assignment to the Pacific Fleet report to the Fleet Aviation Specialized Operational Training Group, Pacific (FASOTRAGRUPAC), Naval Air Station, North Island, San Diego, California for 20 weeks of training after they graduate from AW "A" school. The first 4 weeks are spent in the AW Common Core Acoustic Analyses Course, where AWs receive training in the complex cognitive tasks of acoustic analysis, integration of acoustic intelligence information, and target classification procedures. In previous research on the retention of procedures and knowledge gained in that course, Wetzel, Konoske, and Montague (1983) found that AWs' analysis skills and memory of acoustic intelligence degraded significantly within 4 weeks after course completion. The level of initial learning, which is a prime variable in resisting forgetting (Hurlock & Montague, 1982), depends on the amount and quality of instructional practice. Therefore, the quality of the methods used for instructing these critical and complex tasks and the methods used to test whether students understand the concepts underlying them need to be evaluated.

Objectives

The objectives of this effort were to evaluate the quality of instructional methods used to teach the complex tasks of acoustic analysis and classification at the Common Core course and to recommend course changes that would improve initial acquisition and long-term retention of the skills and knowledge required to perform those tasks.

APPROACH

Selection of Evaluation Criteria

Hurlock and Montague (1982) reviewed literature concerning the retention of skills and knowledge and identified three variables that influence both the initial acquisition and the retention of complex cognitive skills. These variables are listed and elaborated on below:

1. Structural organization of course content.

   a. Students should be provided with a mental model of the task that emphasizes relationships between facts, rules, procedures, principles, and concepts underlying the task.

   b. Presentation of the instructional material should enforce the coherency of the mental model to facilitate the recall of facts, rules, principles, and concepts.

   c. Each content area presented in the course should be taught, practiced, and tested as a skill that supports the primary task.

   d. Course learning objectives should require the student to perform the task skills, not recall or recognize verbal descriptions of the task.

2. Quality of feedback and remediation.

   a. Students should be provided with explicit feedback about their performance.

   b. Feedback should be provided on all subparts of the task, as well as at procedure end-points or as a result of performance on tests.

   c. Feedback should include error diagnosis consistent with the student's mental model of the task.

   d. Remediation of conceptual weaknesses identified by error diagnosis should be specific to the needs of the individual student.

3. Testing methods used to evaluate student performance.

   a. The type of test must be appropriate to the type of performance required; that is, courses that teach cognitively complex tasks should measure student progress in terms of the quality of conceptual understanding of the relationships between facts, rules, principles, and concepts.

   b. Test questions that measure student's conceptual understanding should be administered orally in a fill-in or short-answer format.

   c. In cases where administrative constraints preclude oral testing, questions should be formatted as "paper and pencil" simulations that reveal the quality of the student's conceptual understanding and promote posttest diagnosis of conceptual errors.

   d. Multiple-choice tests that require the student to recognize discrete facts should be avoided.

These three variables were selected as the criteria for evaluating the quality of instruction of complex tasks at the Common Core course. These variables and related research are decribed in the following paragraphs.

Structural Organization of Course Content

Navy course design has been heavily influenced by rules and procedures of instructional system design (ISD). Although the various models for developing instructional matrials recognize the importance of good instruction, instructional technology has yet to develop effective guidance for organizing complex subject matter. The instructional quality inventory (IQI) (Ellis, Wulfeck, & Fredericks, 1979) provides clear and detailed guidance for the writer or lecturer to follow when presenting small units of knowledge (e.g., facts, principles) but was not intended to provide guidance in developing the organizational framework for the entire course. The lack of systematic guidance has resulted in the development of courses that are inadequate for teaching cognitively complex tasks.

Bunderson, Gibbons, Olsen, and Kearsley (1981) discussed the problems that commonly occur in developing skill-oriented courses. Initially, expert performance of a task is analyzed to produce a list of verbal descriptions of the task. These descriptions become the basis of the written instructional objectives that form the backbone of the course, as well as the lessonware that is developed to support the learning objectives. After students have completed the course, they are tested on their ability to recall or recognize the verbal descriptions of the task. It is expected that, at some point, the student will be able to "discover" a model of the expert's performance of the task from the verbal descriptions that will enable him or her to perform the task.

Smith and Reigeluth (1982) stated that at least part of the inadequacy of training matrials developed to teach complicated skills could be attributed to the choice of subject matter and to the organization of materials. They also stated that many courses compound this inadequacy by following an exhaustive, detailed, linear presentation, apparently with the objective of conveying stores of detailed information for later recall and application. This approach ignores the important relationships betwen topics, requires brt .. force memorization, overloads processing ability, provides no context for retrieval, and demotivates through tedium. Evans and Braby (1983), in an assessment of 37 Navy technical courses, found that as much as 50 percent of the content of lessons is isolated information not applied in follow-on lessons. They suggest that many courses are structured so as to exclude distributed practice in application of newly acquired skill. This could account for low retention and transfer of learned skills to follow-on courses and to the job. Because of the course organization, students are required to memorize a vast number of discrete facts by rote. It is difficult to learn and retain by rote memorization. Greeno (1982) stated that, before learning can occur, the material must be related to some general structure or principle; in rote learning, the new procedure or information is simply associated with the specific problem situation in which it is experienced. Training that requires students to memorize large amounts of facts will result in poor performance because their conceptual understanding of the task will be limited and their ability to generalize rules to novel situations reduced.

The type of training best suited to teach complex, cognitive knowledge and skills emphasizes conceptual understanding of the task. Smith and Reigeluth (1982), in their development of a structural strategies model, emphasized the need for overall course development based on the type of task that is to be trained. For tasks that require students to learn a set of underlying principles needed to interpret phenomena or solve

problems, they recommended that the student be provided with a framework or model that emphasizes the causal relationships between principles, concepts, and procedures. For instruction to be effective, the conceptual model that is provided must promote the student's ability to explain, predict, or diagnose a large number of events, problems, or effects (i.e., as encountered in passive acoustic analysis, electronic countermeasures, manuevering). Within the conceptual framework of the model, the student can be taught the principles that explain "how" or "why" an event occurs and then be given practice in applying the principles in a number of situations. Because the student can be exposed to only a limited number of situations in a training environment, the training must be organized so that the student thoroughly understands the rules, principles, and concepts underlying the task, thus ensuring his or her proper performance when novel events or problems are encountered.

Bunderson et al. (1981) promote the use of a similar strategy. They describe a "work model," where the student can practice performing the task under conditions that are contextually much closer to "real work" conditions than are the verbal descriptions provided in many classrooms. Stevens and Collins (1978) also support the use of conceptual or "mental" models in instruction. They consider mental models of physical properties to be important in understanding complex systems and emphasize that those models must represent those systems accurately. They suggest that models must be powerful enough to allow the student to consider alternatives and derive predictions about novel situations. The student should be able to look at alternative situations by running the model with different values assigned to its variables to help him or her understand the concepts underlying the device or process the model is representing.

Conceptual models like those described above have been found to be important in the learning of complex tasks. For example, Greeno (1982) showed the importance of designing instruction to teach geometry students to learn the underlying concepts needed to represent a problem graphically before applying the rule-based procedures to solve it. Substantial variation was found among student performance in solving new problems that had the same structure as those they had previously learned to solve. Students who had been taught the underlying concepts of such problems were better able to solve the new ones than were those who had been taught the procedures without explicitly being shown the structure of relations in the problems. Rumelhart and Norman (1980), in documenting the progress students made in learning a computer editing system, demonstrated the types of errors resulting from faulty mental models of computer behavior. Students who did not have a good mental model of computer functions were more likely to make errors and less likely to be able to generate a reasonable approach to correcting those errors than were others.

Quality of Feedback/Remediation

There is a considerable body of research documenting the importance of receiving quality performance feedback when new skills and knowledge are being acquired and for maintaining those skills. Feedback can range from providing simple corrections on tests to providing detailed diagnostic evaluation of the student's conceptual errors. Branson, Rayner, Cox, Furman, King, and Hannum (1975) stated that providing students with feedback about their performance is a fundamental concept in the development of instruction. They suggested that the effect of feedback on learning is best when it can be provided continuously throughout the task performance. In addition, feedback should be provided with sufficient diagnosis of errors to enforce the coherency of the mental model that is appropriate to the task the student is trying to learn. According to Branson et al., feedback is not as effective when it is provided only at end-points of task performance or

as results of tests, because it does not provide the learner with the explicit information as to what can be done to improve performance.

Briggs (1977) also emphasizes the diagnostic use of feedback for remediating student errors in conceptually-based tasks. He states that, when a student's performance is only partly adequate, feedback needs to be given to define the kind of additional study needed to improve it. This type of feedback is important because it explicitly tells the student where his or her conceptual understanding is weak and provides appropriate practice to correct that weakness. Gropper (1980) notes that, under certain conditions, students can generate feedback about their own performance. They can most easily generate feedback when performing tasks that depend on the correct sequencing of steps that do not require the application of learned principles for correct completion. In these types of tasks, the failure to complete the procedure is evident to the student (i.e., equipment does not function, displays are not available). Self-generated feedback on cognitively complex tasks would require that the student thoroughly understand the concepts underlying the task. This type of feedback would require the students to have a model with which to compare their own responses to determine the correctness of performance.

Testing Methods Used to Evaluate Student Performance

The types of tests selected to evaluate student performance must be appropriate to the type of performance being tested. Tests of student performance in courses that require students to acquire complex knowledge and procedures must emphasize the level of conceptual knowledge gained by the student. However, such tests are not used much in Navy technical schools. There are problems associated with both the kinds of tests used and the interpretation of student performance on the tests. Weiss (1979) points out that the testing procedures used are almost invariably those based on a testing technology developed in the 1920s. Almost without exception, paper-and-pencil tests are used to measure student performance. An example of this problem in the Navy is the emphasis on the use of the multiple-choice test format, which evaluates students' performance on the basis of their ability to recognize discrete facts (NAVEDTRA 110; NAVSEA OD 45519). These tests continue to be used, no matter how irrelevant performance on multiple-choice, fact-recognition questions is to the kind of performance required on the job, primarily because of ease of test administration and familiarity with the format.

Much of the performance that needs to be assessed on complex, cognitive tasks is the level of conceptual understanding attained by the student. Cornbach (1949) suggests that tests that assess levels of understanding often are not used because facts and procedures loom so large in the usual classroom that teachers and test designers have emphasized them out of proportion to other types of outcome. He points out that, although it is important to measure gains in knowledge and skill, a student may earn a high score on a test covering only memory-type material and yet have made little progress toward acquiring a good cognitive organization of that knowledge. The problem with limiting the assessment to tests of factual knowledge is that facts that are little understood are quickly forgotten. Tests of ability to apply principles do not require the student to state or recognize a fact but, rather, to solve a new problem in which that principle is relevant. If the student can determine the correct solution to a new problem that has not been studied and defend that solution with sound principles, it is more likely that he "understands" the principle underlying that problem.

Recent work by Ellis and Wulfeck (1982) provides more specific guidance in selecting appropriate test item format for the type of performance being tested. They recommend that fill-in or short-answer items be used for testing conceptual understanding of complex

tasks. These questions should be administered orally rather than in written format to avoid problems of misinterpretation as well as to allow the instructor to probe for greater detail if the student's answer is not complete. If this procedure cannot be used because of administration problems or time constraints, they recommend a special form of multiple-choice questions called a "paper-and-pencil" simulation. These types of questions, if the incorrect alternatives are constructed carefuly, can effectively diagnose problems in the student's logic at arriving an answer. It is implicit in this recommendation that the student's incorrect responses be used to diagnose and correct the conceptual misunderstanding that caused the error.

Description of Common Core Acoustic Analysis Course

This section describes the Common Core Acoustic Analysis Course in terms of the three criteria described above.

Structural Organization of Course Content

The course includes instruction on five separate knowledge topics and two procedures. The knowledge topics are (1) sonobuoys (types, uses, and characteristics), (2) oceanography (sound channels, the velocity of sound, and the physics of sound), (3) sources of sound, (4) sound source signature characteristics, and (5) acoustic intelligence parameters for specific classes and types of ships. The two procedures are (1) a systematic acoustic analysis procedure that provides the student with guidelines for interpreting sound source information on the lofargram, and (2) a computational procedure that is comprised of a number of mathematical equations and that provides a method to compute relationships among sound sources as they are represented on the lofargram.

The course is structured such that the first four knowledge topics and both procedures are presented to the student during the first week; and the last knowledge topic (acoustic intelligence parameters for specific classes and types of ships), during the last 3 weeks. This information is presented in a linear format, with acoustic intelligence parameters for each class of ships being detailed on separate days. Generally, students listen to lectures on one or two ship classes in the morning and attend a follow-up gram analysis practice lab specific to that day's lecture topic in the afternoon. In addition, they spend some time each day in math labs that allow them to practice using the equations from the computational procedure appropriate to the specific intelligence parameters learned that day.

A review of the course objectives revealed that each segment has a terminal objective that requires the student to "recall" factual information (e.g., specific intelligence parameters, operating charateristics of equipment, or acoustic signature characteristics) about the material presented in the lectures. However, in actual practice, the student only has to recognize the correct answer on a multiple-choice test. Furthermore, a partial criterion is imposed on test performance accuracy: The student is required to recognize only 75 percent of the factual answers correctly. The terminal objectives for the procedural skills require that the students be able to demonstrate their ability to perform the procedures as tested on multiple-choice knowledge tests. None of the course objectives require the student to be able to perform lofargram analysis in an integrated fashion on a performance test or to classify a target using lofargram analysis skills. Therefore, there are no objectives that require trainees to use the factual or task descriptive information they have learned to solve typical problems likely to be encountered on the job.

Quality of Feedback/Remediation

The students are provided feedback in a number of ways:

1. They are encouraged to ask questions during the lectures. The instructors make every effort to answer those questions during the class period. If they cannot answer the question, they refer the question to other instructors.

2. Because of the low instructor/student ratio, opportunity exists for one-to-one interaction during the math and gram labs.

3. The students receive feedback about performance on weekly tests on knowledge factors, computational skills, and gram analysis and classification skills.

Remediation is made available to students under two conditions. Students who are not able to pass the tests and have been approved by the school review board are usually "set back" and allowed to take the course over. Students who meet the "pass" criterion, but whose test scores are low, are included in the mandatory study group and required to attend 2 hours of extra class per day. However, during those 2 hours, they do not review the material that was tested by the exam but, rather, the material presented in that day's lecture. No specific remediation course material has been developed to train students who have been identified as low performers.

Testing Methods Used to Evaluate Student Performance

The student's progress on course objectives is measured by four tests, usually given at the end of each week of the course. The first three tests examine student proficiency on information and skills gained in the preceding week. The fourth is the course final and covers both knowledge factors and gram analysis skills gained over the entire course.

The three weekly tests are divided into two subparts. The first part tests students' performance on acoustic analysis and classification on 10 lofargrams. The students are required to annotate the grams, demonstrate the use of the systematic analysis procedure, and integrate the acoustic intelligence appropriately to derive the correct target classification. The second part is a 40-question, multiple-choice test that evaluates students' recognition of knowledge factors. This test also includes word problems that test the students' ability to use the computational formulas and input appropriate acoustic intelligence information.

RESULTS AND DISCUSSION

Structural Organization of Course Content

Four major probems were identified concerning the course's structural organization:

1. There is no clearly defined conceptual model that promotes the students' understanding of the important relationships between topics. This lack of a conceptual model of the task reduces the students' ability to recall or infer needed information because they do not understand the relationships among the facts, rules, principles, and concepts underlying the task.

2. The information is presented in a linear fashion with the emphasis on topics or discrete knowledge factors, forcing the students to spend most of their energy on rote memorization of a large number of facts.

3. There is no practical application of information learned in the oceanography and sonobuoy segments of the course. Although these topics add considerably to the students' memory load requirements, no realistic practice occurs that would result in useable and measureable skills. It would be more appropriate to include these segments at a point in the training pipeline where the information could be applied and practiced.

4. The course's learning objectives do not require students to perform the skill of acoustic analysis and classification on the lofargram.

Although it is not explicit, the real objective of the present course is to teach students to identify targets displayed on the lofargram using acoustic analysis and classification procedures. Acoustic analysis skill is largely based upon a conceptual understanding of the relationship between sound generated from various sources (i.e., engines, propellers, and auxiliary sources) and the representation of that sound on the lofargram. This skill is not presently being taught so that the student can accurately predict, for example, how changes occurring within the propulsion system will affect representations that occur on the lofargram. Sound source characteristics are taught during the first week of school, and students are shown diagrams of the various propulsion systems. However, there is no continual, systematic demonstration of the intractive relationship between the two domains.

To promote a systematic approach, students should be provided with a mental model of the task that emphasizes the relationships between sound sources and their representations on the lofargram. This model should be based on the mechanical and mathematical relationships among the components within the propulsion systems and their relationship to other target sound sources that will allow generation of the appropriate lofargram signature. It should provide a conceptual understanding of (1) propulsions systems and other sound source generators, (2) the mathematical relationships among components of the propulsion system, (3) the ways in which the propulsion system and other sound source generators are represented on the lofargram, and (4) how changes in the propulsion system will effect the lofargram signature.

There are a number of advantages to the student associated with using a model that meets these criteria.

1. The student will have a much better way of interpreting the acoustic information on the lofargram because he or she will better understand the sound source that generated that information.

2. Because this model is based upon the mechanical and mathematical relationships among the components of the propulsion system, the student can manipulate the component variables (i.e., number of blades, prime mover characteristics, type of drive system) to generate alternative examples of the class of ships being studied. This will be particularly valuable in understanding the lofargram representation of ships with multiple engines and drive systems, as well as in showing the relationship of auxilliaries to propulsion system changes.

3. The model should provide the student with a better information structure for remembering the acoustic parameters associated with particular types of ships and reduce the need for rote memorization of those facts.

This model should also be useful to the instructor staff. Presently, demonstration of lecture points about representations on lofargrams is limited by a small training gram library. Often the grams used for demonstration do not clearly and uniquely reinforce the curriculum. This model should provide the instructor with a way to demonstrate systematically the changes on the lofargram due to variables such as propulsion system component differences, speed, and depth, as well as provide a way to compare aspects of different but similar classes of ships. It is likely that one of the most useful applications of this model would be to provide the instructors with a method for diagnosing conceptual errors being made by the students. These errors should be more easily corrected by demonstrating the error as being in conflict with the concepts that underlie the model. Tests could also be developed that would be aimed toward assessing the qualitative understanding of the course content as well as recall of acoustic intelligence and appropriate use of analysis procedures. This model should be used throughout the course to gain initial conceptual understanding of the acoustic analysis procedures and to reinforce those concepts while teaching parameters of specific ship types.

The learning of the conceptual, "mental" model could be facilitated by computer-based instruction (CBI). A mathematical model could serve as the basis for an intractive, generative CBI system. The capability to use the model to generate grams would provide a more systematic demonstration of the effects of individual variables that affect the lofargram signature. The ways in which the student could interact with the materials could also be more varied. In addition, a significant reduction in both programming time and system size would be realized because of the systematic approach afforded by use of this model.

Quality of Feedback/Remediation

Although the instructor staff makes a concerted effort to provide performance feedback to the students, there are three major problems in the way feedback and remediation are administered:

1. The quality of diagnostic feedback for repeated errors in subprocedures is inadequate. Feedback and correction of conceptual errors is not performed in a systematic way that ensures the student's understanding of the cause of error.

2. Students have no way of evaluating their own performance largely because of the lack of an appropriate mental model of the task.

3. There is no systematic approach to remediation of poorly understood knowledge or procedural skills.

Feedback about the correctness of performance can occur in a number of ways. Feedback given to students for performance on practice exercises and tests of various types is often limited to knowledge of the number of correct responses to items included on the test, with varying amounts of explanation for items that were answered incorrectly. In tests of performance on complex procedural tasks, errors in subprocedures may receive little attention in the test review process. In particular, in testing situations observed, little or no diagnostic feedback was given to students concerning repeated

errors in a given subprocedure that occurred over the range of problems presented in the test. If the conceptual error that caused the mistakes in the subprocedure is not explicitly identified and corrected, the student is likely to make the same mistakes in the future.

The instructors in this course make a concerted effort to provide feedback to students while in class, during the gram labs, and following the tests. It would be difficult for them to provide high quality, individual feedback in the gram labs about repeated conceptual errors due to the number of students and the fact that grams are evaluated as they are completed and not as an individual package. The weekly tests provide a better framework for this type of feedback. Presently, a group of instructors grades the grams as they are finished by the students, primarily to save time, as there are 10 grams per student and from 12 to 15 students. To provide the kind of quality feedback needed, a single instructor should review the packet of grams for individual students to discover those repeated errors. Although students review the grams in an after-test session, they are not likely to discover these types of errors by themselves and be able to correct their mistakes.

Students scoring a low passing grade on one of the weekly tests are assigned to the mandatory night study group where they spend an additional 2 hours per day in studying models. However, they do not review the material on which they scored a low grade but, rather, the material presented earlier that day. The rationale is based on the idea that students with low passing grades simply need to be exposed to material for a longer time than do those with higher grades. The real problem is that the conceptual errors that caused the students' poor performance are not identified and corrected.

Some way is needed to provide students remediation when they do not completely understand material, particularly when repeated errors indicate conceptual misunderstanding. The students could be provided with practice time on specific procedures. One suggestion would be to develop gram/math lab packages for use by students who need additional practice on those procedures. If the students make a large number of errors involving incorrectly recalled acoustic intelligence parameters, the information structure used by the student could be reviewed to provide some insight to the problem. Those students could be helped in developing and understanding that information structure, as well as allowed time to practice the recall of those items. It would probably be helpful to all students if time were set aside in class for practice of recall of those parameters. Although the classification procedure requires the accurate recall of acoustic intelligence parameters, the classified status of those parameters makes it impossible for students to study them at night on their own; further, each day's lecture adds considerably to the material that needs to be remembered. Unless a specific time is set aside to review the material, students will find it difficult if not impossible to recall specific parameters accurately.

Testing Methods Used to Evaluate Student Performance

The primary problem in the area of knowledge testing is that the students' progress in meeting course objectives is measured by their ability to recognize discrete facts in a multiple-choice format, rather than demonstrate whether they understand fundamental relationships by solving typical problems. The emphasis of the testing does not allow for diagnostic analysis of conceptual misunderstanding.

Most of the questions on the present knowledge test are aimed at testing the student's ability to recognize discrete facts (i.e., number of blades, type of prime mover, type of drive system). Because of the conceptual nature of this task, questions that probe the student's conceptual understanding should be included. Examples of those types of questions might be:

1. How will a change in a particular drive system affect the lofargram signature on a specified contact?

2. How will an increase in speed affect the various components of the propulsion system as represented on the lofargram?

3. How will a change in the gear reduction ratio affect the relationship between the prime mover and the propellers?

The student's answers to these types of questions will not only demonstrate the level of the student's understanding but also provide the instructors with a good diagnostic tool to better understand the problems that the student is having with the material.

The types of tests used to evaluate the level of student knowledge of discrete facts (e.g., specific items of acoustic intelligence) are limited to the multiple-choice test format. Students are tested on their ability to <u>recognize</u> correct answers contained in a group of possible answers rather than recall the appropriate information from memory. The testing is, therefore, inconsistent with the objectives. When these students are performing tasks on the job, they will be required to recall this information, not recognize it from a group of possible answers. Therefore, it would be better to evaluate the student's performance by using the job standard of recall rather than the multiple-choice standard of item recognition. This could be accomplished by using questions that require fill-in answers, short answers, or listing of facts. Multiple-choice questions could be used to assess student performance on computational questions if the alternative answers are designed to reveal weaknesses in the procedures or acoustic intelligence recall required to solve the problem. However, these types of questions should be used only if the intent is to diagnose student errors on these problems and provide the student with corrective feedback.

CONCLUSIONS

1. The instructors and the staff at the Common Core course are both hard-working and consciencious: They made every effort to teach students to become competent acoustic analysts. Although this evaluation revealed a number of deficiencies in course organization, diagnostic feedback, and testing methods, instructor attitude <u>is not</u> cited as a problem. It is very likely that these deficiencies have been, in part, overcome by individual instructor efforts. However, relying on this type of unsystematic approach cannot ensure high quality graduates of this school.

2. The Common Core course, as it is presently being taught, does not explicitly provide the student with a qualitative understanding of the relationship between the sound source generators in the propulsion system and their representations on the lofargram. The development and use of a model should (a) provide a better conceptual understanding of this relationship that will aid the student in the initial acquisition of the skills and knowledge underlying acoustic analysis and classifiation techniques, (b) provide a better

information structure for the retention of the procedural skills and the memorized acoustic intelligence data base, and (c) aid the instructors in curriculum development, classroom demonstrations, and test development.

3. Although the student is provided with feedback about performance on knowledge and procedural skills, little individual feedback is directed toward diagnosing and correcting repeated errors caused by conceptual misunderstandings. This type of feedback could be provided by an individual instructor reviewing test results, rather than by a group of instructors grading the lofargrams from many different students. Feedback of this quality should aid the student in understanding the underlying concepts of the task.

4. Tests of knowledge factors do not presently require the students to demonstrate conceptual understanding of the material. Without these types of questions, students may be encouraged to employ rote memorization learning techniques. Although such techniques enable students to perform adequately on a test, they may limit their ability to use the information to perform well at a later time. In addition, tests are presently constructed to test the students' recognition rather than recall of material presented during the course. The students would be better prepared for the job if they were tested on their ability to recall specific information.

RECOMMENDATIONS

It is recommended that FASOTRAGRUPAC support the following actions:

1. Improve the Common Core course by the development, evaluation, and use of a model designed to increase the students' conceptual understanding of the relationship between sound sources and the representations of those sounds on the lofargram. The course curriculum would be developed around those principles and incorporate the model of the task.

2. Ensure that students use the model to structure acoustic intelligence parameters and be allowed class time to practice the recall of those items.

3. Ensure that information presented in the oceanography and sonobouy segments of the course is taught, practiced, and tested as skills needed to perform acoustic analysis and classification. If practical application of that information cannot be accomplished in this course, those segments may be moved to a more appropriate point in the training pipeline.

4. Ensure that course objectives require students to perform the skill of acoustic analysis and classification of the lofargram.

5. Ensure that instructors systematically attend to problems of student misunderstanding and provide diagnostic feedback to individual students about the conceptual errors in their understanding of the task as evidenced by repeated errors in subprocedures.

6. Ensure that tests assess the student's level of conceptual understanding of the materials presented in the course, as well as the student's ability to recall rather than recognize factual information.

7. Ensure that remediation of students who perform poorly on these tests is directed toward correcting the poor performance rather than requiring students to study new material for a longer period of time.

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